The Technical Advisory Committee (TAC) for the Elk Valley Water Quality Plan (the "Plan") held their 3rd meeting on November 25-26, 2013. This document is a record of the technical advice received after this meeting.

The TAC process is structured around a review of work packages submitted to the TAC in advance of their meetings by Teck. These work packages relate to the analytical process that Teck is undertaking to inform decisions around the selection of water quality targets, management scenarios, and any additional monitoring and studies that will be included in the Plan. The advice in this table relates primarily to work packages that were reviewed and discussed at TAC Meeting #3.

The focus of TAC Meeting #3 was a review of Work Package #6a, which provided information on Teck's Water Quality Planning Model. This model is being used to estimate future water quality conditions in the Elk Valley under a range of management scenarios. Each management scenario is a combination of different mitigation measures that could be applied to improve water quality conditions. An additional focus of the meeting was Work Package #5, which provided information on the mitigation measures that Teck is considering for the Plan.

Summary Table

Category	#	Description of Post Mtg "Technical Advice"	Rationale
Site Specific Water Quality Objectives **Work Package 3** *Methods and Calculation Values*	**B3-1**	Recommend conducting a site-specific study to set a new selenium target for Lake Koocanusa. *For additional context refer to Technical Comment Memo supplied by US & MT Governments (dated December 13, 2013)*	The selenium target set in the Order for Lake Koocanusa was not based on site-specific conditions in the reservoir. Rather, it appears that the target was determined using province-wide selenium guidelines. However, monitoring indicates that water-quality concentrations are already above the alert levels noted in the 2012 Draft BC Selenium Guidelines (2012), hence the trigger point for further action has already been exceeded. A site-specific study therefore needs to be conducted in Lake Koocanusa to determine an appropriate selenium target that protects fish, aquatic life, terrestrial life, and human health in a lentic environment. This study and subsequent targets need to be developed to consider bioaccumulation factors, reservoir dynamics, source loadings, migratory populations, and natural conditions.
Water Quality Planning Model **Work Package 6a** *Methods and Assumptions*	**B3-2**	Recommend one or more hydrologic models with physically-based, watershed parameters suited to the local hydrologic regime be calibrated and validated to quantify similarities / discrepancies with the **historic modelling** results produced from GoldSim.	This recommendation will help to address uncertainty in the selected empirical approach, quantify comparability to standard hydrologic modelling approaches, and create a range of possible futures for Water Quality Modelling.
	B3-3	Recommend a physically-based hydrologic model be used for all **simulations of future flows** for input into the WQM.	The ability to manipulate and change watershed physical characteristics is the standard approach to investigate future flows and changes via hydrologic drivers. The GoldSim approach, however, relies on developing empirical (mathematical) relationships to simulate current and future flows. This empirical

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			relationship is based solely on data and static watershed conditions (not future). From a scientific basis, the assumption that an empirical relationship is valid in the future after a watershed has been disturbed is one of high uncertainty.
	B3-4	Strongly recommend using only good quality hydrologic data that has been collected to a published hydrometric standard (e.g., WSC or BC Govt. RISC standards [RISC 2009]) for input into hydrologic models. Fair, poor, incomplete, or other data that does not meet the standards of data collection under a provincial or nationally recognized protocol should not be used.	As the approach relies on mathematical relationships, high quality data is critical to the process. The available data varies in quality from very high (Environment Canada) to fair / poor quality. The report cites 26 watersheds that Teck monitors. However only 22 are listed in Table 3-1 (+1 EC station). Most of the listed data in table 3-1 is self-rated as Poor (9), or Fair (9). Only 4 stations are rated as good quality. The majority of measurements are weekly (Mar. – June) and monthly (rest of year) spot measurements. Some continuous data is collected. It is unknown if these data are all spot water level readings or if they are discharge measurements (water level and flow).
	B3-5	Recommend clarifying Teck Flow measurement protocol: • data collection standards, • data collected, • staff training protocol and (re)certifications, • instrumentation used (e.g., flowtracker, Price AA, others?), • continuous data logging equipment (i.e., data logger model, accuracy and precision) used • equipment maintenance and calibration protocol, • process for developing rating curves for each site and the rating curves produced, • variability in the annual rating curves, and • whether the quality of data as a result of the above are comparable to WSC collected data and if not what effect this may have on the modeling result.	As the approach relies on mathematical relationships, high quality data is critical to the process. It is important to know what data collection protocol (e.g., if RISC 2009) were used. This is important in confirming that data from WSC and Teck are comparable (i.e., WSC/EC data are continuous measurements that conform to ISO standards. EC-WSC are the highest standard of hydrometric data available).
	B3-6	Recommend following the advice of the 2012 *Water and Air Baseline Monitoring Guidance Document for Mine proponents and Operators* http://www.env.gov.bc.ca/epd/industrial/mining/pdf/water_air_baseline_monitoring.pdf	The flow metrics generated by GoldSim were monthly, max and min monthly flow (10 year return). However, the BC guidance document (2012) for *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* recommends using the 7Q10 for low flows (i.e., lowest 7 day annual flow, 10 year return stat) and the maximum flow (10 year return stat). **These statistics can be quite**

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		Specifically, as per pg. 120, generate the 7Q10 and the 10 year maximum (peak daily or instantaneous) discharge vs. monthly statistics produced by GoldSim. Include a description of how average monthly values are compiled from hydrometric stations that only possess weekly to monthly spot reading data. Describe the plotting position used in frequency analyses.	**different** from the statistics of monthly values simulated by GoldSim. For example, the 7Q10 will likely be much lower than the lowest monthlyQ10 presented in the report. This is important for pollution dilution calculations input into the water quality model.
Management Scenarios **Work Package 5** *Mitigation Measures*	**C3-A**	(Comment) Recommend identifying and describing which of the Teck stations in the report are not representative of the total yield of the upslope watershed. Describe how the basins were adjusted to account for the limitations previously mentioned and how this affects uncertainty of simulation results.	The report states that "Many of the Teck flow monitoring stations were installed to satisfy other site requirements (such as reporting for effluent discharge permits) and are located accordingly (e.g. at the decants for sediment ponds). Flow measurements at these locations are often unrepresentative of the total yield of the watershed because of issues such as conveyance and sediment pond leakage, bypass and measurement challenges (e.g. safety concerns at high flows)." This makes the data from them unsuitable for hydrologic model calibration/validation if they are not representative of the basin.
	C3-B	(Comment)Recommend re-plotting graphs to make the differences between simulated and observed more apparent (i.e., reduce line thicknesses, adjust size / width, plot observed vs. simulated on a yearly basis vs. 15 years).	The graphs used to show goodness-of-fit between observed and simulated flows are not of a scale that shows the differences easily to the reader. The graph lines are thick and by lumping all 15 years of data together, the compressed differences between simulated and observed seems to be minimized. However, even with these limitations in graphical presentation, it is apparent that in some graphs (e.g., fig 5-4) simulations tend to over-estimate the low end of the hydrograph in many years. As mentioned previously, this is important to refine as minimum flows are likely the area of greatest concern with respect to water quality (i.e., future flows may be over predicted in the low flow season).

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	C3-C	(Comment) Recommend discussing the uncertainty associated with using Cataract and Porter Cr. How were the limitations on pgs. 34-35 addressed? Discuss the additional uncertainty that not addressing these factors (pg 34-35) creates in the simulation results. Provide an objective rationale of removing the "anomalous" data points beyond what is provided. Discuss how/why instantaneous spot measurements need to be consistent with neighboring monthly instantaneous spot readings. Discuss the statistical basis /rationale for their removal.	Of the representative analogue for mining areas of the Teck stations, only 2 watersheds (Cataract and Porter Cr) met the criteria set out in the report for suitability. Of those two watersheds, neither was determined to be suitable due to the rationale present on pg 34-35. Irrespective of these points, Cataract Cr was selected as the mining analogue. Further, three "anomalous" readings were removed from the record of Cataract Cr. The report states the anomalous observations were out of sync with other monthly observations. However, from a science perspective this is not out of the ordinary when taking spot (instantaneous) readings and not necessarily a rationalization for removal from a statistical basis.
Site Specific Water Quality Objectives **Work Package 3** *Methods and Calculation Values*	**B3-7**	Utilize the 5th percentile water hardness for the reference stations to derive Site-Specific Water Quality Objectives (SSWQOs) for sulphate and cadmium. Recommend revising the technical memorandum entitled "Calculation of Site-Specific Water Quality Objectives for Selenium, Sulphate, Nitrate, and Cadmium in Support of the Elk Valley Water Quality Plan" to address this advice. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Step 1 of the Site-Specific Water Quality Objectives (SSWQOs) derivation process involves identification of the B.C. water quality guidelines (BC WQGs) for each of the chemicals of potential concern (COPCs) that are named in the Order. For total selenium and nitrate, the 30-d average or maximum WQGs can be used directly as presented in the WQGs documents. However, the WQGs for sulphate and cadmium are hardness dependent. Teck (2013) used the median water hardness for the Fording River station (FR_UFR1) and Elk River station (GH_ER2) to calculate the preliminary SSWQOs for sulphate and cadmium. However, such SSWQOs may not be protective during periods when water hardness is less than the median values. For this reason, an estimate of the lower limit of water hardness (e.g., 5th percentile) should be used to calculate the preliminary SSWQOs for sulphate and cadmium.
	B3-8	Develop a table that presents the recommended Site-Specific Water Quality Objectives (SSWQOs) for total selenium, nitrate, sulphate, and total cadmium for the Elk and Fording Rivers. The table should explicitly indicate the period of the year in which the SSWQO applies (e.g., spring	Teck (2013) derived Site-Specific Water Quality Objectives (SSWQOs) for total selenium, nitrate, sulphate, and total cadmium for the Elk and Fording Rivers. Table 5 of the document presents the preliminary SSWQOs as specific values for total selenium and

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		freshet, recession, low flow) and define the duration of each period (e.g., low flow period is December through March). Recommend revising the technical memorandum entitled "Calculation of Site-Specific Water Quality Objectives for Selenium, Sulphate, Nitrate, and Cadmium in Support of the Elk Valley Water Quality Plan" to address this advice. *For additional context refer to MacDonald letter (dated December 3, 2013)*	nitrate, and as ranges for sulphate and total cadmium. However, the document does not include a table that presents the final recommended SSWQOs for these substances. For this reason, a table should be created that explicitly describes the recommended SSWQOs for each river.
	B3-9	Develop a list of substances and media types for which Site-Specific Water Quality Objectives (SSWQOs) are required, based on exceedances of the BC WQGs. Derive SSWQOs for each substance in each media type included on the list. Recommend revising the technical memorandum entitled "Calculation of Site-Specific Water Quality Objectives for Selenium, Sulphate, Nitrate, and Cadmium in Support of the Elk Valley Water Quality Plan" to address this advice. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Teck (2013) derived Site-Specific Water Quality Objectives (SSWQOs) for total selenium, nitrate, sulphate, and total cadmium in surface water for the Elk and Fording Rivers. However, other substances have the potential to exceed BC water quality guidelines in surface water, sediments, or tissues in the Fording River, Elk River, and/or Lake Koocanusa. For this reason, the available surface water chemistry, sediment chemistry, fish-tissue chemistry, invertebrate-tissue chemistry, and bird-egg tissue chemistry should be reviewed and evaluated to identify exceedances of BC guidelines according to the definition of an exceedance as defined in these guidelines. The SSWQOs should be established for any substance for which exceedances of the BC water quality guidelines have occurred within the period of record. BC guidelines are considered to be applicable for all other substances.
	B3-10	Derive Site-Specific Water Quality Objectives (SSWQOs) for total selenium, nitrate, sulphate, and total cadmium in Lake Koocanusa, including season-specific SSWQOs if warranted by variability in water quality conditions. Recommend revising the technical memorandum entitled "Calculation of Site-Specific Water Quality Objectives for Selenium, Sulphate, Nitrate, and Cadmium in Support of the Elk Valley Water Quality Plan" to address this advice. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Teck (2013) derived Site-Specific Water Quality Objectives (SSWQOs) for total selenium, nitrate, sulphate, and total cadmium for the Elk and Fording Rivers. However, SSWQOs were not recommended for Lake Koocanusa. For this reason, SSWQOs should be derived for total selenium, nitrate, sulphate, and total cadmium in Lake Koocanusa. The seasonal variability in water quality conditions is a key factor that needs to be considered during SSWQO deviation, if the WQGs are not adopted directly as SSWQOs.

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Water Quality Planning Model / Hydrology and Water Quality *Work Package #6a*	**B3-11**	Modify the water quality planning model to provide a reliable tool for predicting water quality in Lake Koocanusa (i.e., not just at the mouth of the Elk River). The water quality planning tool also needs to consider effects on sediment quality and tissue chemistry, if it is to provide a reliable basis for decisions-making in the Elk Valley. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Model Domain - The water quality planning model was developed to simulate concentrations of cadmium, selenium, nitrate, and sulphate at selected stations in the Fording and Elk rivers. While simulations of historic and future water quality conditions in the Fording and Elk rivers are directly relevant to the water quality planning process, predictions of future water quality conditions in Lake Koocanusa under various management scenarios are also required because the Lake is in the designated area of the Ministerial Order and is a receiving water body. Therefore, the water quality planning model should be modified to facilitate prediction of water quality conditions in Lake Koocanusa. This work needs to be completed with a timeframe that informs decisions taken during the development of the EVWQP.
	B3-12	Modify, if necessary, the water quality planning model to provide a reliable tool for predicting water quality conditions in the tributaries to the Fording and Elk rivers that are affected by coal-mining activities. Report the results of water quality predictions for all coalmining affected tributaries and utilize these results in the EVWQP development process. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Model Domain - The water quality planning model was developed to simulate concentrations of cadmium, selenium, nitrate, and sulphate at selected stations in the Fording and Elk rivers. While simulations of historic and future water quality conditions in the Fording and Elk rivers are directly relevant to the water quality planning process, predictions of future water quality conditions in the tributaries to these rivers are required to evaluate the costs and benefits of various candidate mitigation measures and management scenarios.
	B3-13	The Elk Valley Water Quality Plan needs to include the development of a mechanistic model to facilitate predictions of the concentrations of cadmium and nitrate in tributaries, the Fording River, the Elk River, and Lake Koocanusa. Compare the performance of the empirical and mechanistic models, and select the more reliable model for use in water quality planning in the Elk River watershed. Develop a strategy for collecting information relevant to model refinement and for refining the water quality planning model(s) as additional information is generated. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Based on the results of water quality modeling conducted to simulate historical conditions, it appears that the water quality planning model may provide a relevant basis for predicting the concentrations of certain water quality variables (e.g., selenium, sulphate), but not for other variables (i.e., nitrate and cadmium). These inconsistencies in model performance suggest that key mechanisms controlling the release and/or transport of certain variables may not be adequately accounted for in the model assumptions and/or model development. For this reason, development of mechanistic, rather than empirical, model is likely

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			to be more effective for nitrate and cadmium. This work needs to be completed within a timeframe that informs decisions taken during development of the EVWQP.
	B3-14	Revise the water quality planning model by incorporating predictions of the influence of climate change on hydrological conditions and other variables considered in the water quality planning model. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Currently, the water quality planning model does not include the potential effects of climate change on hydrological conditions in the Elk Valley or on other variables that are included in the model. However, climate change has the potential to influence climatic conditions in the future and such changes should be accounted for in the water quality planning model. For this reason, relevant climate change models should be reviewed to identify potential climate-related effects in the Elk Valley. This information should be used to adjust assumptions related to future hydrological conditions and other variables considered in the water quality planning model.
	B3-15	Extend water quality modeling to encompass a post-closure period of 100 years for coal mines in the Elk Valley. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Currently, the water quality planning model provides simulations of historical conditions (i.e., 2004 to 2012). This model will be used as a basis for making predictions regarding future water quality conditions in the Elk and Fording rivers. To ensure that such predictions provide a fulsome basis for decision making regarding water management options, water quality predictions should extend at least 100 years beyond closure of coal mines in the valley.
Monitoring / Water Quality Planning Model	**B3-16**	As part of the development of the aquatic effects monitoring program within the Elk Valley Water Quality Plan, include water quality monitoring and stream flow monitoring at the modeling nodes included in the water quality planning model. The frequency and duration of monitoring at each location should be determined with input from the TAC. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Model Inputs - The water quality planning model is dependent on estimates of stream flows and water chemistry at 35 nodes within the Elk River watershed. For the purpose of model development, the required information has been estimated based on hydrological monitoring data and estimation procedures, as well as water quality monitoring data and estimation procedures. In the future, simultaneous water quality monitoring and hydrological monitoring should be conducted at each of these nodes to provide the information needed to validate and refine the water quality planning tool.

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Sediment Modeling	**B3-17**	Develop a planning model to facilitate predictions of COPC concentrations in sediments within tributary streams, the Fording River, the Elk River, and Lake Koocanusa. Report the results of the sediment quality predictions for the tributary streams, the Elk and Fording rivers, and Lake Koocanusa and utilize these results in the EVWQP development process. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Model Domain - The water quality planning model was developed to simulate concentrations of cadmium, selenium, nitrate, and sulphate at selected stations in the Fording and Elk rivers. This approach assumes that predictions of surface water chemistry provide the necessary and sufficient information for evaluating management scenarios and developing the EVWQP. However, adverse effects on fish and other aquatic organisms can also occur as a result of exposure to sediment-associated COPCs. For this reason, an approach to modeling the concentrations of selected COPCs in sediments needs to be developed to support the EVWQP.
Water Quality Planning Model / Management Scenarios	**B3-18**	Develop alternate assumptions regarding the efficacy of various types of covers (including no cover, simple covers, complex covers, and geomembrane-incorporating covers) for reducing net percolation and loadings of contaminants to receiving waters in the Elk Valley. *For additional context refer to MacDonald letter (dated December 3, 2013)*	Based on the information that was presented during the TAC meeting, it appears that the geochemical inputs assume no decreased contaminant loading in association with cover placement over waste rock piles (i.e., decreased infiltration into waste rock piles is assumed to result in increased residence time and, hence, increased concentrations of constituents of potential concern in seepage). This assumption creates a strong bias against incorporation of covers into the overall water quality plan for the Elk Valley. As the assumption regarding the impact of covers on contaminant loadings is not supported by any data, a range of alternate assumptions should be developed and incorporated into the water quality modeling activities.
	B3-19	Ensure that the water quality planning tool and associated elements are designed in a manner that facilitates timely consideration of alternative information, different assumptions, and/or refined management scenarios, as provided by the TAC and/or the public. *For additional context refer to MacDonald letter (dated December 3, 2013)*	While a number of management scenarios are being developed for consideration during development of the EVWQP, it is likely that the TAC will provide specific advice regarding the modification or refinement of the management scenarios and/or underlying assumptions. Therefore, it is important to develop the water quality planning tool and associated elements in a manner that facilitates efficient consideration of alternative information, different assumptions, and/or refined management scenarios.
	B3-20	Clearly identify all of the assumptions and information inputs that are used to develop and evaluate the various management scenarios that are	The development of management scenarios that provide a basis for meeting short-term, medium-term, and long-term targets will

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Management Scenarios		considered during formulation of the EVWQP. For each management scenario, prepare a table that identifies the information requirements, documents the information or assumptions used, and the rationale/source of the information or assumptions. *For additional context refer to MacDonald letter (dated December 3, 2013)*	require a substantial number of assumptions and information inputs. These underlying assumptions and information inputs need to be clearly documented and referenced to provide confidence in the EVWQP that is ultimately established.
	B3-21 *(formerly #B3-7)*	Recommend including climate change forecasts (via Climate WNA or alternate multiple emissions scenarios) in the hydrologic model simulations of future flows. Describe how will the projected changes in the amount, form and timing of precipitation affect streamflow discharges from the simulated watersheds. How will the changes in watershed characteristics, influence the accumulation and melt/ runoff of precipitation in the future.	This will allow the development of a range of possible futures for input into the WQM Climate Change as part of the future flows is an important driver and was not discussed or considered in the flow forecasts. For example, in this area (Using Climate BC) Natal Peak near Sparwood could see an increase in Winter Precipitation (255 mm up to 267-321 mm), Summer ppt is likely to decrease from 173 mm to 160-138 mm. The effects of changing climate and precipitation amount/timing are critically important hydrologic drivers and subsequently affect future flows and water quality. The report states that specifically "leaching effects (both concentrations and loadings) are expected to vary seasonally in response to changes in infiltration caused by snowmelt and other climatological events. High flow events may expose more rock to leaching resulting in higher chemical loads but may also provide dilution leading to lower concentrations." This is important for the WQM.

References (if provided)

MacDonald, D. 2013. Letter to Lynn Kriwoken (*TAC Chair from MOE*) from Donald MacDonald (dated December 3, 2013). MacDonald Environmental Services Ltd (MESL). *Representative on the TAC for Ktunaxa Nation Council.*

Teck (2013). "Calculation of Site Specific Water Quality Objectives for Selenium, Sulphate, Nitrate and Cadmium in Support of the Elk Valley Water Quality Plan". Technical Memorandum written by Golder Associates, November 12, 2013.

US and Montana Governments. 2013. *Memo - Technical Comments for Work Products Supplied for TAC Meeting #3 United States Government and State of Montana* (dated December 13, 2013).